Undam It? Klamath Tribes, Social Ecological Systems, and Economic Impacts of River Restoration

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Like the miner's canary, the Indian marks the shifts from fresh air to poison gas in our political atmosphere; and our treatment of Indians, even more than our treatment of other minorities, reflects the rise and fall in our democratic faith. — Felix S. Cohen

Introduction

Tribal communities face many serious challenges, and with respect to self-determination, environmental protection, natural resource management, and sustainable development are among the most salient.[1] Nested arrays of federal, state, and tribal stakeholders are involved in managing these polycentric issues throughout Indian country. This is the case in the Klamath River Basin, a region along the California-Oregon border that has become a focal point for local, national, and international discourse on issues including water law, science and policy, dirty politics, environmental governance, and indigenous sovereignty.[2] Ecological issues in the basin were brought to the forefront when severe drought conditions in 2001 exacerbated competition for scarce water resources, triggering a high profile issue of policy implementation with the Endangered Species Act. This amplified conflict among several interests: farmers, anglers (commercial and

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sport), other recreationists, federal wildlife refuge managers, environmental organizations, and state, local, and tribal governments. After years of intense struggle, a comprehensive and final settlement agreement proposing to remove four dams on the river, restore basin water resources, and create economic opportunities for tribes was signed on April 18, 2014 by more than forty signatories, including the Klamath Tribes, US Secretary of the Interior Sally Jewell, and federal and state leaders. Among others, it was approved by the Klamath Basin Task Force, the irrigation community, fishermen, and federal, state, and local representatives.[3] It represents a monumental step in the long history of water wars in the American West. The tribal chairman of the Klamath Tribes recently noted that the dams have blocked salmon from his tribe since construction and he is fully supportive of the agreement, stating "Our members voted for it in a referendum, there was an overwhelming majority in support."[4] Developing collaborative solutions to address fresh water conflicts is one of the greatest challenges of this century, reinforcing the need for a new decision-making paradigm.[5]

This paper presents an overview of the various historical, cultural, environmental, and economic forces that converge in the river basin. Two crucial questions are explored: (1) What key factors influence environmental governance in the region? and (2) How might proposed dam removal impact socioeconomic conditions? Accordingly, key variables, potential tradeoffs, and next steps are examined. This is achieved through the use of the Social Ecological Systems (SES) framework and general economic evaluation, which provide a preliminary but important step in characterizing the complex and interdependent issues. Also, a multidisciplinary perspective is recommended through use of the Integrative Dam Assessment Modeling (IDAM) tool to advance decision-making by stakeholders.

Background

United States Indian Policy

Although often discussed collectively, it is important to remember that American Indian tribes are very diverse, numbering 566 federally recognized, state-recognized, and unrecognized tribes with disparate socioeconomic and political systems.[6] It is also worth noting that Native Americans living on reservations have the deepest poverty of any identifiable groups in the United States—with family poverty rates three times the American average—and related social stresses such as excessive unemployment (30–90 percent), high suicide rates, poor health, and high crime.[7] As the result of historic actions and precarious states of trust, there can be a delicate cadence between the tribes and other federal, state, and local government entities. Moreover, power, influence,

and decision-making uncertainties complicate intergovernmental relations, especially with respect to natural and cultural resources. Nevertheless, federal policies and practices have fostered self-determinism for tribes and catalyzed progress in key social, cultural, and economic indicators.[8]

For background and perspective, it is helpful to summarize the history of US federal policy with respect to Native Americans. Generally, this is captured in six phases: (1) discovery, conquest, and treaty-making; (2) removal, relocation, and reservations; (3) allotment and assimilation; (4) reorganization and self-government; (5) termination; and (6) self-determination.[9] These periods illuminate current issues affecting sovereignty, management, and governance.

Tribal sovereignty is an essential concept on which the distinct relationship with the United States federal government is built. Monette examines the overlapping and often conflicting spheres of federal, state, and tribal sovereignty in terms of federalism.[10] Generally, Native American tribes have two primary instruments for exercising control with respect to communities, land management, and natural/cultural resources: inherent sovereignty and federal trust responsibilities. Sovereignty represents independence, authority, and the power to govern tribal members and reservation lands.[11] On the other hand, trust responsibilities, as confirmed by the Supreme Court, designate the tribes as "domestic dependent nations" vis-à-vis the United States government, and not states, thereby creating a federal duty to protect tribal interests.[12] While the courts have had varying interpretations of the extent of (limited) sovereignty powers, it has been recognized that tribes are distinct political entities. For example, after generations of violent salmon battles in the Puget Sound region of Washington state, the historic 1974 opinion in *United States v. Washington* (later upheld by the Supreme Court) reinforced the sovereignty of tribes as governments to regulate the harvest of salmon by tribal members and boldly reaffirmed the validity of tribal treaty rights.[13] More recently, in 2013 President Obama expressed a strong commitment to tribal communities in Executive Order 13647, which established the White House Council on Native American Affairs:

> [R]especting the sovereignty of tribal nations is critical to advancing tribal self-determination and prosperity . . . the ability of tribal governments to determine how to build and sustain their own communities—is necessary for successful and prospering communities. We further recognize that restoring tribal lands through appropriate means helps foster tribal self-determination.[14]

Another pivotal factor for collaborative governance in the Klamath Basin is the political environment. Even with fluctuating political party control, both Republicans and Democrats in the Executive Office and Congress have generally promoted self-determination and self-governance for tribes—although

for ostensibly different rationales. Nonetheless, in the midst of the economic downturn, this equilibrium has become increasingly unstable due to recent Republican initiatives against tribal sovereignty in the interest of siding with state and local governments.[15] Overall, collaborative governance in the Klamath Basin takes place in a nexus of federal, state, and local interests as well as convoluted political jurisdictions that influence power dynamics.

Klamath Tribes

Located in the upper basin, and comprised of three historically separate tribes—the Klamath, Modoc, and Yahooskin—the Klamath Tribes have inhabited the Klamath River Basin for thousands of years, with lifestyles and heritage revolving around the natural resources of the area.[16] Multi-tribal and multi-village gatherings have been important sociocultural traditions, including those celebrating fish runs.[17] Salmon and suckers have been essential to the physical, economic, and spiritual health of the Klamath tribes for generations.[18] Extensive trade networks were established with tribal ties throughout the Pacific Northwest region.[19]

The reservation era was initiated with the Klamath Tribes Treaty of 1864, with more than 23 million acres of ancestral land ceded to the United States.[20] In 1872, in response to the US government's arbitrary decision to force consolidation of rival tribes onto the Klamath Reservation to accommodate white settlers, approximately fifty Modoc warriors led by Kentipoos (also known as Kintpuash or Captain Jack) were able to stave off more than one thousand United States cavalry soldiers for nearly a year. Kentipoos and other tribal leaders were hanged at Fort Klamath on October 3, 1873.[21] The three signatory tribes, addressed together as the Klamath Tribes, reserved rights to hunt, fish, and gather plants into perpetuity. Over the years, tribal lands were incrementally diminished. As part of the 1887 General Allotment Act, approximately 25 percent of the original Klamath Reservation was transitioned from collective to individual ownership, including non-Indians. Although the reservation had been reduced to about half of its original area of 2.2 million acres, the Klamath Tribes were relatively self-sufficient based on timber and grazing activities.[22] With the construction of a sawmill in 1870, the arrival of the railroad, and a large stand of Ponderosa pine effectively managed for long-term yield, the Klamath Tribes became one of the most economically prosperous tribes in the United States.[23] However, as part of aggressive US federal policies toward cultural assimilation, in 1954 the Klamath Termination Act "terminated" the Klamath Tribes.[24] As a result, they lost federally recognized status, supplemental services, and land assets in exchange for cash payment. Suddenly, in a single action, the Klamath Tribes had gone from the second wealthiest

tribe in the nation to a community with poverty levels three times greater than their non-Indian neighbors. Part of the former reservation land was sold and the rest became part of the Winema National Forest and Klamath Marsh National Wildlife Refuge.[25]

The Termination Act did contain provisions that provided ongoing fishing rights to Indians on the former reservation. Federal court rulings in 1974 and 1984 confirmed that hunting, fishing, gathering, trapping, and water rights were retained, together with consultation rights for land management decisions.[26] On August 26, 1986, official federal recognition of the Klamath Tribes was restored under the Klamath Restoration Act.[27] Although the land base of the reservation was not restored, efforts are underway to reacquire property and continue building governance capacity. Since restoration, core capabilities have been strengthened through the general council, tribal council, tribal courts, and various commissions, departments, and services. Among the more than fifty departments and programs operated by the tribes is a culture and heritage department, which endorses a tribal language program, and a natural resources department, which works for environmental protection pursuant to treaty rights and various intergovernmental agreements and local partnerships.[28] The essence of the Klamath Tribes' perspective on their land and the journey of water through it is expressed by Elwood Miller, former director of Natural Resources for the Klamath Tribes: "When we go out into the land, we can literally feel the permanent presence of our people throughout history, a sense of belonging that cannot really be described to others; in our neck of the woods, that's where the waters begin; it jumps out of the ground right there in the Klamath country and begins its trek toward the ocean and ends up down in Yurok territory on the coast."[29]

Study Area

The Klamath River Basin is one of the most biologically diverse regions in North America. Located in southern Oregon and northern California, it was once the third-largest producer of salmon in the United States.[30] Six federally recognized Native American tribes are located in the Klamath River Basin: the Yurok Tribe, Resighini Rancheria, Hoopa Valley Tribe, Karuk Tribe, Quartz Valley Indian Community, and the Klamath Tribes. The watershed is generally divided into upper and lower basin regions that are somewhat isolated from each other (fig. 1). The upper basin sits on a high arid plateau with shallow lakes and marshes and contains Upper Klamath Lake, while the lower basin is a steep forested landscape with many tributaries ultimately flowing into the Pacific Ocean. Settlement by European immigrants in the area began with explorers, fur trappers, and missionaries, followed by livestock ranchers and

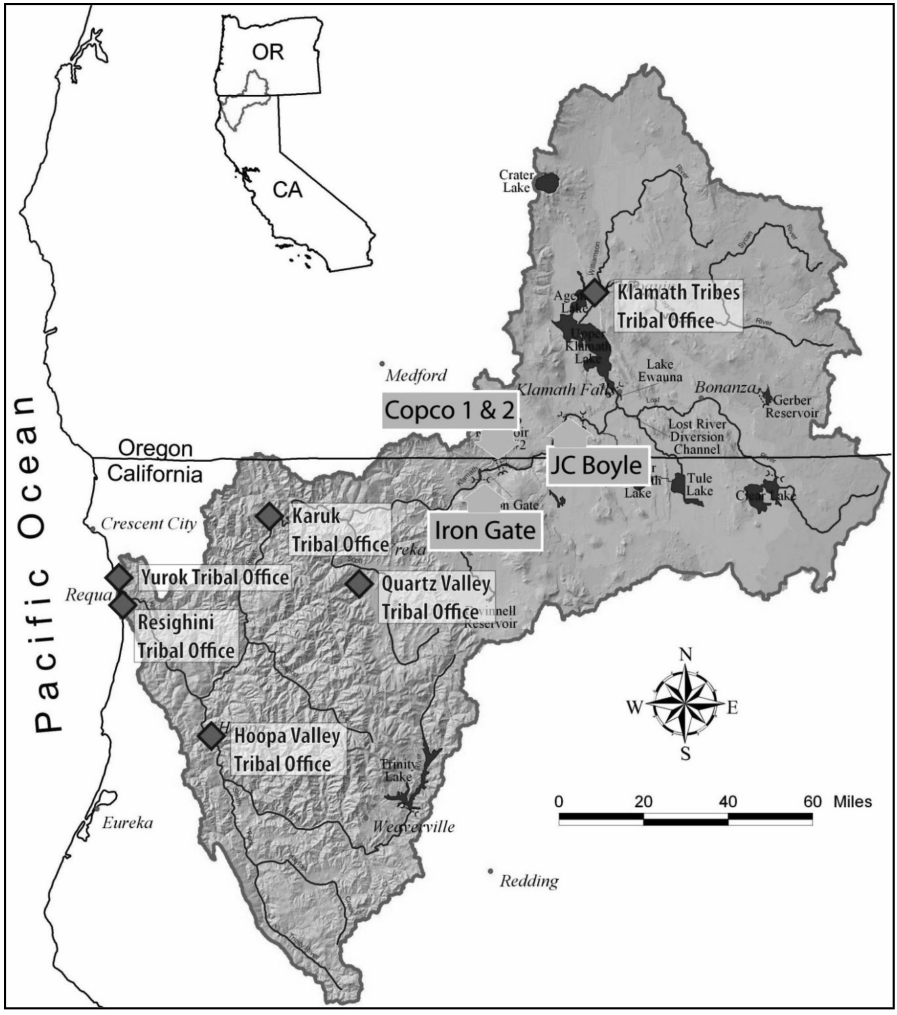

Figure 1. *Klamath River Basin including Water Resources, Four Dams Considered for Deconstruction, and Tribal Governments. Source: Klamath Settlement Group, 2011.*

farmers. These latter settlers were encouraged by federal irrigation projects that provided cheap land, water, and power; the state allowed early irrigators to claim and maintain almost all water rights, the doctrine of prior appropriation.[31] White settlers showed little regard for the rights and interests of Native people or those of fish and wildlife in the region. Consequently, indigenous communities in the basins were further marginalized and destroyed.

As part of the Reclamation Act of 1902, in the early twentieth century a series of seven dams were constructed along the Klamath River to support irrigation and hydroelectric power.[32] This conversion has had severe ramifications

for the riverine ecosystem and surrounding communities.[33] Water quality has been impaired, together with substantial impacts to flora and fauna throughout the broader watershed. Accompanying the reclamation infrastructure facilities and intensified agriculture were elevated chemical contamination, decreased water flows, increased water temperatures, enhanced vulnerability to excess nutrients that promoted algal blooms, and drastically depleted fish species—including suckers and salmon, the most important food for the tribal communities in the area. This has led to adverse impacts on physical, mental, and socioeconomic health for the tribes.[34]

Conflicts over water and fish resources among conservationists, tribes, farmers, fishermen, and state and federal agencies have become increasingly contentious and expensive.[35] Competing interests include irrigation for agricultural products; threatened and endangered species; federal waterfowl refuges; commercial, sport, and subsistence fishing; electric power; recreational uses; and cultural livelihoods. This complex polycentric system has posed challenging conundrums for stakeholders. With a drought exacerbating risky conditions, pursuant to the endangered species and tribal trust requirements in support of water requirements for suckers and coho salmon, in 2001 the US Bureau of Reclamation (BOR) diverted water from irrigation uses to downstream flows below Iron Gate Dam.[36]

Disagreements of Science, Management, and Policy

Issues of water allocation and wildlife management intensified with the listing of threatened and endangered species as part of the 1973 Endangered Species Act. Although water flows were controlled by the BOR for decades, an ecological sequence of threatened species inhabiting the river basin triggered federal court involvement: bald eagles were listed as threatened in 1967, Lost River and shortnose suckers in 1988, and coho salmon in 1997. The two species of suckers and the coho caused the administrative interventions in 2001.[37] When the BOR submitted a required biological assessment to the US Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) that included recommendations for flow levels below Iron Gate Dam that were consistent with business as usual, a technical review team comprised of representatives from several federal, state, and tribal organizations considered them too low and objected strenuously to the proposed levels.[38] Both the FWS and the NMFS issued opinions concluding that the proposed actions would harm threatened and endangered species,[39] stakeholders on both sides of the issue initiated litigation, and it was determined that water allocation modifications were necessary to protect the suckers and salmon.[40] For the first time in nearly a century, priorities for fish had won over the objections of farmers.[41]

Incensed farmers filed a lawsuit against the United States and the issues triggered high-level political involvement, including intervention by Vice President Dick Cheney.[42] The secretary of the Interior requested assistance from the National Research Council, part of the National Academy of Sciences.[43] Scientific uncertainty and translating professional judgments into management and policy decisions were at the center of the debate. In February 2002, the National Research Council issued a report, finding that there was "no substantial scientific foundation" for the irrigation reduction and full irrigation was resumed in March 2002.[44] Subsequently, in September 2002 one of the biggest fish kills in United States history occurred in the lower Klamath River Basin—at least 33,000 salmon expired in shallow, warm, pathogenic waters.[45]

Environmental Governance

The convergence of American Indian affairs and environmental policy presents a fertile arena for scholars and practitioners to advance understanding of social ecological systems (SES). Given the increased recognition of the complexity and nature of interrelated environmental, economic, and social problems, it is necessary to look for boundary-spanning, interdisciplinary, and adaptive approaches. To effectively address these critical issues, collaboration between and across levels of government is crucial. A useful construct can be an *environmental governance* that embodies the rules, practices, policies, and institutions responsible for shaping how humans interact with the environment. According to the United Nations Environmental Programme, environmental governance can be defined or characterized as:

> Multi-level interactions (i.e., local, national, international/global) among, but not limited to, three main actors, i.e., state, market, and civil society, which interact with one another, whether in formal and informal ways; in formulating and implementing policies in response to environment-related demands and inputs from the society; bound by rules, procedures, processes, and widely-accepted behavior; possessing characteristics of "good governance"; for the purpose of attaining environmentally-sustainable development.[46]

To operationalize this into a practical method of analysis requires the use of an appropriate conceptual framework.

Approach

Social Ecological Systems Framework

Frameworks can provide conceptual maps for grounding theories from differing contexts to find a common language.[47] This allows for theory comparisons

and model testing within an analytic structure. The importance of sustainability frameworks is illustrated by the report from the National Research Council, *Sustainability and the U.S. EPA*, which attempts to identify and blend concepts across programmatic boundaries.[48] Since being published in "A Diagnostic Approach for Going Beyond Panaceas," the Social Ecological Systems (SES) framework has been widely discussed, inspiring research, feedback, and refinement through a growing network of international scholars investigating common pool resources, which consist of natural or human-made resouces whose characteristics make it difficult to exclude potential beneficiaries.[49] With foundations in the prominent Institutional Analysis and Development (IAD) framework and related institutional design principles, the SES framework further emphasizes biophysical dimensions in intergovernance settings.[50] Elinor Ostrom illuminated the nexus between the IAD and SES during her 2009 Nobel Prize lecture, "Beyond Markets and States: Polycentric Governance of Complex Economic Systems."[51]

The SES framework was designed as an interdisciplinary tool for discerning difficult problems faced by stakeholders. By defining core factors and delineating their interaction and outcomes in a tiered format, the framework facilitates systematic evaluation of human-environmental dilemmas. The first tier accounts for overarching characteristics of the resource system; resource services and units; actors; and governance system embedded in larger social, economic, and political settings and related ecosystems (fig. 2). These components are linked to more specific explanatory and contextual variables within additional tiers (fig. 3). This then fosters further theoretical understanding through the development and use of precise models for the given action situation. The IAD framework and elements of the SES framework have been applied globally in comparative case studies and meta-analysis across various sectors such as forestry, irrigation, fisheries, and technologies.[52] Utilizing the SES framework for indigenous communities in the United States presents a promising opportunity to better understand baseline conditions toward building capacity and improving environmental governance in support tribal self-determination.

In light of the historic conflicts along the Klamath River, the intricacy of the social ecological systems is clear. Therefore, with proposed dam removal and river restoration a question emerges: What factors influence environmental governance?

Posited Variables

To begin answering this question, the multi-tiered diagnostic SES framework was applied. As described by McGinnis and Ostrom, effective use of the framework involves a three-step procedure.[53] The process builds on progressively

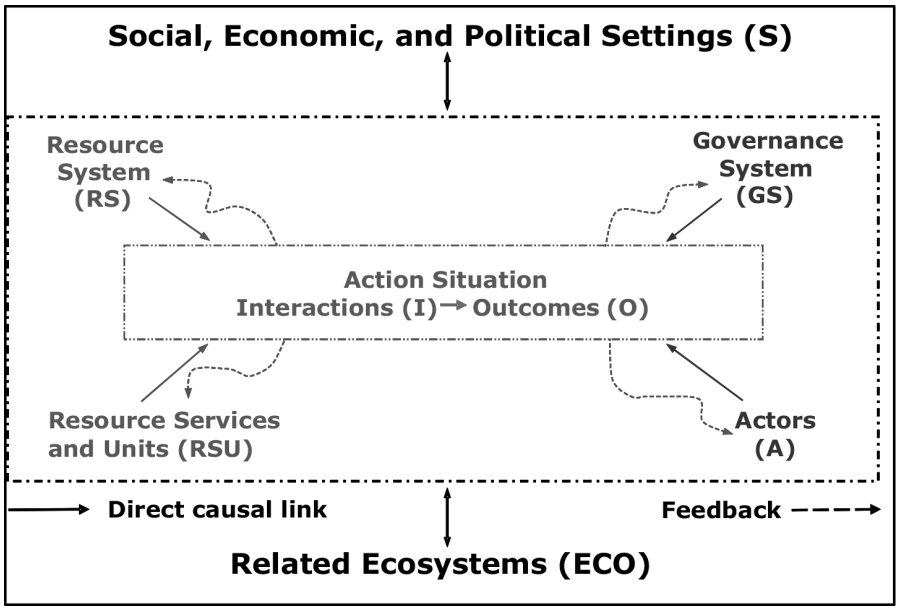

Figure 2. *Action Situations Embedded Within Tier 1 Social Ecological Systems. Source: Adapted from Ostrom, 2007.*

Social, Economic, and Political Settings (S)
S1- Economic development. S2- Demographic trends. S3- Political stability.
S4- Government resource policies. S5- Market incentives. S6- Media organization. S7- Technology

Resource Systems (RS)

RS1- Sector (e.g., water, forests, pasture, fish)
RS2- Clarity of system boundaries
RS3- Size of resource system
RS4- Human-constructed facilities
RS5- Productivity of system
RS6- Equilibrium properties
RS7- Predictability of system dynamics
RS8- Storage characteristics
RS9- Location

Governance Systems (GS)

GS1- Government organizations
GS2- Nongovernment organizations
GS3- Network structure
GS4- Property-rights systems
GS5- Operational rules
GS6- Collective-choice rules
GS7- Constitutional rules
GS8- Monitoring and sanctioning rules

Resource Services and Units (RSU)

RSU1- Resource unit mobility
RSU2- Growth or replacement rate
RSU3- Interaction among resource units
RSU4- Economic value
RSU5- Number of units
RSU6- Distinctive characteristics
RSU7- Spatial and temporal distribution

Actors (A)

A1- Number of actors
A2- Socioeconomic attributes of actors
A3- History of use
A4- Location
A5- Leadership/entrepreneurship
A6- Norms (trust-reciprocity)/social capital
A7- Knowledge of SES/mental models
A8- Importance of resource (dependence)
A9- Technology used

Action Situations: Interactions (I) → Outcomes (O)

I1- Harvesting levels
I2- Information sharing
I3- Deliberation processes
I4- Conflicts
I5- Investment activities
I6- Lobbying activities
I7- Self-organizing activities
I8- Networking activities
I9- Monitoring activities

O1- Social performance measures (e.g., efficiency, equity, accountability, sustainability)
O2- Ecological performance measures (e.g., overharvested, resilience, biodiversity, sustainability)
O3- Externalities to other SESs

Related Ecosystems (ECO)
ECO1- Climate patterns. ECO2- Pollution patterns. ECO3- Flows into and out of focal SES.

Figure 3. *Further Specified Second Tier Variables within Social Ecological Systems. Source: Adapted from Ostrom, 2007.*

more specific levels of analysis involving framework, theory, and model usage. This limited baseline assessment represents an initial step of organizing contextual information, characterizing the action-situation, and identifying potentially relevant variables. Based on studies by Gutierrez and collegues, Cox and collegues, Basturo and Ostrom, and Ostrom, multiple variables for fisheries and irrigation systems have been posited as vital for collective action.[54] For this particular case, the ten second-tier variables suggested by Ostrom are evaluated; the action situation is based on interactions and outcomes relating to the proposed dam decommissioning.[55] Although the central question addresses current conditions, with the Klamath Tribes in the upper basin as the focus of analysis, for reference a limited comparison is described based on settings associated with two other timeframes: historical pre-dam (before 1906); and future projected dam removal conditions (beyond 2013).

The core subsystems for Tier 1 are defined as: the resource system (fig. 2, RS) is the upper Klamath River basin; the resource units (fig. 2, RU) include water and fish; the governance system (fig. 2, GS) involves Klamath Tribes (historical) and nested broader collaborative entities (present and future); and the actors (fig. 2, A) are comprised of Klamath Tribes (historical) and multiple organizations involved with the settlement agreement (present and future). In addition to the set of ten Tier 2 variables widely identified as important for self-organization, five other variables were considered particularly salient (see table 1).

Historical view—perspective and variables. While capricious and contentious, early US Indian policies were consistent with classic responses to perceived "tragedy of the commons" problems, as famously presented by Hardin.[56] The approaches to managing common pool resources utilized by many tribes did not coincide with US governmental goals and preferences. Many reformers thought that the traditional tribal ways of communalism could be improved through agrarianism and assimilation, endeavors much more congruent with the individualistic focus of American society.[57] Especially during the allotment and termination eras, this contributed to paternal prescriptions for governmental actions, parceling of tribal lands, and externally imposed private ownership. These policies did not account for sophisticated tribal institutions already in place for generations throughout the Pacific Northwest such as those in the Klamath River Basin (table 1, A3). Traditional ecological knowledge and archaeological evidence indicate that indigenous institutions, including potlatch systems of reciprocity, were resilient and sustainable with respect to salmon runs and other resources.[58] Fish harvests were moderated by elaborate systems of proprietorship that assumed the force of law, and access was shared through heredity, gift, or payment.[59] Furthermore, robust resource distribution, trade,

TABLE 1
COMPARISON OF SES FRAMEWORK VARIABLES FOR KLAMATH RIVER BASIN

	Variables	Historical pre-dam (before 1906)	Present dam (1906-2013)	Future removal (beyond 2013)
	ACTORS (A)			
A1	Number of users	Small	Large	Large
A3	*History of use*	High	Moderate	High
A5	Leadership/entrepreneurship	Strong	Conflicted	Collaborative
A6	Norms/social capital	High	Conflicted	Collaborative
A7	Knowledge of SES/mental models	High	Conflicted	Collaborative
A8	Importance of resource	High	Conflicted	Collaborative
	GOVERNANCE SYSTEMS (GS)			
GS3	*Network structure*	High	Conflicted	Collaborative
GS6	Collective choice rules	High	Conflicted	Collaborative
	Resource systems (RS)			
RS3	Size of resource system	High	Low	Moderate/High
RS4	*Human-constructed facilities*	Low	High	Moderate/Low
RS5	Productivity of system	High	Low	Moderate/High
RS7	Predictability of system dynamics	High	Low	Moderate/High
	RESOURCE UNITS (RU)			
RU1	Resource unit mobility	High	Low	Moderate/High
RU 5	*Number of units*	High	Low	Moderate/High
RU 7	*Spatial and temporal distribution*	High	Low	Moderate/High
	Successfully self-organized	Yes	Conflicted	Collaborative*

*Successfully self-organized after conflicts and crises culminating in settlement agreement; DOI final determination and Congressional funding may be contingent factors. Italicized variables are posited in addition to ten suggested by Ostrom (2009).

and bartering systems had been in place within and between tribes to support socioeconomic exchanges and alliances.[60]

Prior to dam construction, water quality and quantity supported strong healthy aquatic communities. Diverse staple fish species were vital to the Klamath Tribes' diet (table 1, A8). Additionally, water quality was important for traditional ceremonies and purifications (table 1, A8); however, since dam construction, rituals have been compromised due to health concerns about consequently impaired waters. Pre-dam water conditions were integral with Native ways of life on many levels. Cultural and spiritual considerations aside, water and other natural resources have been undervalued and subsidized by the federal government, oftentimes benefiting Klamath farmers.[61]

CURRENT CONDITIONS—PERSPECTIVE AND VARIABLES. The Klamath River travels approximately 263 miles and the watershed covers over 12,000 square miles (table 1, RS3). The basin was once a fertile and productive ecosystem generating

between 660,000 and 1.1 million spawning adults each year (table 1, RS5). As part of the federal reclamation and irrigation project of 1906, an extensive network of constructed facilities including seven dams, three reservoirs, hundreds of miles of canals and laterals, numerous drains, pumping plants, and tunnels altered the landscape (table 1, RS4).[62] According to government documents, the current wild adult spawning population is estimated to be less than one percent of its former abundance in some parts of the river.[63] In many upper reaches of the river basin above the dams, salmon and steelhead have not been sighted for nearly one hundred years (table 1, RS7). Numerous anthropogenic practices have been identified as responsible for the overall decline; in addition to the dams, logging, road building, grazing and mining activities, and several other activities have been identified as contributing factors.[64] With nearly 140 wildlife species consuming salmon and steelhead directly and indirectly via the food web, diminished populations have had dramatic effects throughout the basin's ecosystem.[65]

Proposed future—perspective and variables. As characterized in table 2, based on modeling predictions, the proposed dismantling and removal of the four dams (Copco 1 and 2, J. C. Boyle, and Iron Gate) are expected to improve both water and aquatic resources. Water flows would follow the natural hydrology more closely (table 1, RU1), and water quality effects are projected to be better in the long term. Habitat conditions and ecosystem functions for invertebrates, anadromous, and resident fish are expected to be enhanced (table 1, RU5).[66] Moreover, restoration of aquatic, riparian, and terrestrial resources (table 1, RU7) would strongly support social, cultural, and economic ties between the tribes. This would also facilitate the transmission of traditional ecological knowledge (table 1, A7).[67] Building on the bargaining and compromises that resulted in the settlement agreement between multiple parties, collective intellectual capital capacity could be leveraged for future environmental governance and decision-making (table 1, GS3 and GS6).

The livelihoods of all of the tribal communities in the basin are closely tied to the health of the river system (table 1, A8). Located the furthest upstream, the Klamath Tribes are significantly impacted by the dams. In May of 2004, the Klamath Tribes filed a $1 billion lawsuit against dam operators for damages associated with the loss of salmon in the Klamath River Basin. An application to relicense the dams was filed with the Federal Energy Regulatory Commission (FERC) in 2006.[68] Significant concerns were raised with respect to the environmental impact of the dams as part of the review process. Accordingly, intensive efforts to bring stakeholders in the basin together have been increasingly successful.[69] In addition to a total of more than twenty-five interagency and regional working groups (table 1, A1), the Greater Klamath Basin Stakeholders'

Workshops (table 1, A5) have been particularly effective at engaging groups together in face-to-face dialogue with broad representation and participation—fostering levels of trust and capacity previously unknown (table 1, GS3). In these interactions, the focus has been on local, bottom-up strategies. And the signed hydroelectric and basin restoration agreement (table 1, A6) involving partial or complete dismantling of four dams located on the river, and resulting in one of the largest removal actions of its kind, has been widely supported.[70]

Decommissioning and breaching of the dams and implementation of the agreement requires unprecedented cooperation among multiple public, private, and nongovernmental organizations (table 1, GS6). Given the contested history and intricate issues, the negotiation process has been remarkable. The secretary of the Interior's determination to proceed with the agreement will have significant consequences for communities in the basin and throughout the northwest region.[71] Despite the political uncertainties, the Klamath River Basin will continue to experience transformation, and applying the SES framework contributes to unpacking the multifaceted problems of protecting environmental quality. The identified factors suggest some conceptual orientation for gauging benefits, costs, self-organization, and diagnostics toward planning for subsequent steps. A vital part of assessment includes addressing the financial dimensions of dam removal, which specifically leads to the second research question: How might proposed dam removal impact economic conditions?

TABLE 2
FOUR HYDROELECTRIC DAMS PROPOSED FOR REMOVAL

	Copco 1	Copco 2	J.C. Boyle	Iron Gate
Year operational	1918	1925	1958	1962
Height (m)	38.4	10.1	20.7	59.1
Storage capacity (m3)	57.8 million	90,000	4.3 million	72.5 million
Max Power generating capacity (MW)	20	27	98	18
Upstream fish passage	No	No	Limited	No

Source: DOI, 2012

DISCUSSION

Economic Impacts

The average age of the 84,000 dams in the United States is fifty-two years, and the rising number of high-hazard dams has resulted in a cumulative "D" report card rating by the American Society of Civil Engineers.[72] Many dams are located near indigenous and ethnic-minority communities that have often not been part of the planning or construction processes.[73] Due to a combination

of deteriorating infrastructure, FERC relicensing complications, and growing public support for ecologically based river governance, dam removal in the United States has become an increasingly popular option for local and state jurisdictions.[74]

The important issues surrounding salmon recovery in the Pacific Northwest and the incomplete studies used in the late 1990s provoked concern from economic interests in the region. For example, the Snake River Benefit Cost Analysis prepared by the US Army Corps of Engineers was criticized by scholars and stakeholders for relying on national impacts while ignoring those at the regional level, including those related to subsidies, tribes, and passive use benefits.[75] In 1998, seventy-eight concerned economists sent a letter to government leaders in the Pacific Northwest, urging them "to consider the full range of economic consequences" when making salmon-management decisions. Their principles are noted in table 3 and are generally consistent with Richard D. Morgenstern's recent recommendations for regulatory impact analysis.[76]

TABLE 3
ANALYTICAL PRINCIPLES FOR ECONOMIC ASSESSMENT

Priority	Principle	Guidance
1 Primary	Benefits as well as costs	Removing or keeping a dam would generate economic benefits as well as economic costs. Consider them both to understand the full effect on the value of the goods and services derived from streams, forests, and other resources.
2 Primary	Positive as well as negative impacts on jobs	Dealing with a dam would have both positive and negative effects on job opportunities. Consider them both to understand the full effect on workers, their families, and their communities.
3 Secondary	Distribution of consequences and fairness	Those who enjoy the benefits or jobs of a decision on a dam would not necessarily be the same as those who would bear the costs or job losses. Consider the full distribution of economic consequences to understand who wins, who loses, and the fairness of the distribution.
4 Secondary	Rights and responsibilities	With any decision on a dam, property owners and resource users behave differently than they otherwise would. Consider whether these changes represent infringement of their rights or enforcement of their responsibilities.
5 Secondary	Uncertainty and sustainability	Any decision on a dam would rely unavoidably on information insufficient to guarantee the outcome. Consider fully the potentially high costs from decisions yielding undesirable outcomes that are irreversible or extremely difficult to reverse.
6 Secondary	More than just salmon conservation	Removing or keeping a dam would have a variety of ecological and economic effects, such as changes in the quality of stream water used for other purposes, that may seem peripheral. But consider all the effects.

Source: Whitelaw, et al., 1998

Designated beneficial uses for the Klamath River include: agricultural; ecological; hydropower; industrial; recreational; and drinking water.[77] Attempting to quantify the tradeoffs (costs and benefits) involves assessing both market goods, such as hydropower and commercial fishing, and non-market environmental goods, such as recreational uses, subsistence fishing, and aesthetics.[78] Though a rigorous and exhaustive benefit-cost analysis is beyond the scope of this paper, some key concepts are discussed. It should be noted that assorted public, private, and nongovernmental organizations have performed varying levels of economic analyses with diverging assumptions, alternatives, models, scales, discount rates, and uncertainties. Per the analytical principles outlined in table 2, efforts by the Department of Interior in 2012 appear to generally follow the noted guidance by Whitelaw, et al. (table 3).[79] Accordingly, I have summarized findings from applicable research studies in the following sections.

Potential Benefits

From both biocentric and anthropocentric views, deconstructing the dams and restoring the riverine ecosystem to more natural conditions will likely improve the water quality, aquatic habitat, and riparian species. Many stakeholders would benefit, Native Americans in particular, given that the river is essential for sociocultural livelihood. It is estimated that historically (pre-dam), approximately one million spawning salmon and steelhead were produced in the river each year. Conversely, salmon counts over the 1978 to 2004 time period averaged small percentages of those numbers of salmon per year. While it is generally accepted that the salmon population would return to greater numbers, the specific magnitude and timing are uncertain. While much is unknown about river restoration generally, and the full implications of restoring the Klamath specifically, decisions often rely on modeling predictions. Analogous data (such as the benefits transfer valuation method) may be used from the Snake River dam removals in Washington and Idaho states, where the US Army Corps of Engineers removed four dams at their confluence with the Columbia River. This provides an opportunity for useful proxy information such as society's willingness to pay, which is the standard measurement for valuing benefits associated with production of goods and services.

In addition to the expected return of the salmon, harvest rates and allocation of the salmon stocks are vital considerations.[80] Studies suggest that increases in the salmon harvest would lead to recreational and commercial fishing increases.[81] In addition to fall salmon, the season run most anticipated to increase with dam removal, there are many other important species. This makes quantifying aggregated benefits of the fisheries generally difficult, but the

benefits are likely to be greater than conservative estimates based exclusively on fall salmon.

Based on research contributing to government assessments of the proposed actions, several key effects are noted: expected benefits to fisheries are robust. Chinook salmon are expected to increase average annual production by 83 percent. Also, prized game fish such as steelhead/redband rainbow trout will be enhanced as they return to historical habitat with greater distribution. Coho salmon are predicted to recover significantly, thus helping mitigate their federally listed threatened status. Along with the fish themselves, surrounding conditions will improve and reduce disease outbreaks. There may be some tradeoffs with dam removal; for example, reservoir recreation based on non-native bass, yellow perch fishery, and flat-water boating will no longer be viable. Nevertheless, overall refuge recreation will increase with additional water, biodiversity, hunting, and ecotourism. Other than fishing, the pros and cons of changes in recreational activities associated with the transition from reservoir (lakes) to free-flowing rivers suggest mixed outcomes.

Research from the US Interior and Commerce departments suggest some spatiotemporal variation for ecological indicators within the Basin. Water-quality goals, elimination of the reservoir's toxic algal blooms, and restoration of a more natural thermal regime in the river would be achieved immediately. Other water quality improvement goals, such as nutrient reductions, would be accelerated but could still require decades to achieve. Dam removal could mobilize between one-third and two-thirds of the 13.1 million cubic yards of reservoir sediment. Preliminary chemical testing of reservoir bottom sediments indicates low human health risk. Sediment transport modeling predicts high concentrations of suspended sediments for two to three months. While sediment concentrations could result in near-term lethal effects on some of the coho salmon smolts and steelhead in the river, it would likely be less than 10 percent. Also, data suggest coho salmon, steelhead, and other fish populations would quickly return to 2012 population numbers, with an increase in abundance and viability after dam removal. Planned reservoir drawdown would occur during the winter season to minimize negative effects on sensitive fish species.

According to 2012 DOI estimates, river restoration would have many immediate effects for local communities, including ramifications for flooding and employment.[82] Flooding risks related to reservoir drawdown and dam removal would be minimized and/or mitigated through phased decommissioning. While small increases in long-term flood risks may occur, stakeholders would be actively engaged as part of the planning process to reduce any adverse impacts. Dam removal and ecosystem restoration would create a number of jobs. The one-year dam removal project is estimated by government sources

to result in 1,400 jobs during construction. Implementation of restoration programs is estimated to result in 4,600 jobs over fifteen years. Commercial fishing jobs are estimated in five management zones. Employment stemming from increased gross farm income during the modeled drought years is estimated to range from 70 to 695 average annual jobs. Some jobs would also be lost in the dam management and recreational sectors. As such, forty-nine average annual jobs related to operations and maintenance of the PacifiCorp facilities (a private electric power company owned by Berkshire Hathaway Energy) are estimated to be lost. Furthermore, government reports indicate that employment associated with dam removal would include direct, indirect, and multiplier effects. Direct jobs related to deconstruction involve demolition, operations, transportation, and disposal. Indirect jobs range from equipment manufacturing to maintenance, repair, retail, real estate, and environmental monitoring. The multiplier would account for additional spending generated from initial expenditures.[83] Considering a life-cycle perspective, the increased salmon would also presumably lead to additional jobs across sectors. Additionally, four average annual jobs related to reservoir recreation and fourteen average annual jobs related to whitewater rafting are estimated to be lost.

Dam removal would affect property values in varying ways over the short and long term. The overall effect of these changes is difficult to forecast. Specifically, land values for reservoir frontage, access, or views could decrease in value. Also, land values for river views and river access could increase because of restoration, including improved water quality and more robust anadromous fish runs. Values connected to removal of the dams and river restoration can also include non-use application aspects of environmental good, such as: option value (willingness to pay to preserve future option); existence value (willingness to pay for simply knowing that some environmental amenity exists), stewardship altruistic value (willingness to pay for another's gains including non-humans); and bequest values (willingness to pay for environmental quality for future generations).[84] A Klamath nonuse valuation survey was conducted with both regional and national dimensions: the first component included residents of local counties in California and Oregon, and the second involved a nationwide effort. These data were compiled and used to calculate estimates of total economic value based on household willingness to pay. As noted earlier, decreased fishing has been devastating on many levels, including traditional diet, leading to adverse health effects such as diabetes, obesity, and heart disease, and an overall diminished way of life for the salmon peoples of the Klamath—requiring further specialized and in-depth research to allow economic analysis. In other aspects, some of the values are qualitatively noted because they do not fit economic frameworks.

As described in earlier sections, many Native Americans residing in the basin have spiritual beliefs and traditional practices that are inseparable from the river and surrounding homeland environments. Dam removal and river restoration may help to address what many tribal members view as an historical violation of tribal trust responsibilities by the federal government. Implementation of the agreements would likely have beneficial effects on water quality, fisheries, terrestrial resources, and traditional cultural practices. Dam removal could enhance the ability of Indian tribes in the Klamath River Basin to conduct traditional ceremonies and other indigenous practices. Dam removal and reservoir drawdown could affect Native American cultural resources sites reported to be currently submerged beneath the reservoirs. Human remains may be associated with these sites. Plans to identify cultural resources and to avoid, minimize, or mitigate impacts to those resources are being developed in consultations with the appropriate state and tribal historic preservation offices as well as other Native American organizations.

Potential Costs

Decommissioning and dismantling the dams would take place in phases, and estimated costs vary. Supporting costs are generally related to deconstruction such as removing the physical structures, lost services, and external effects.[85] Preliminary tests indicate that sediments are likely not contaminated. If confirmation testing determined that they did contain hazardous substances, the cost of removal, including any necessary treatment and disposal, would increase significantly. With all of the thorny issues and uncertainties, coordinated studies involving teams of experts are warranted. Based on government estimates, the total cost of full dam removal and associated mitigation is $291 million.[86] As an alternative, studies have proposed an option that would leave some structures in place. This action would still allow a free-flowing river but there would be some additional operations and maintenance needs culminating in a final cost of $247 million.

As noted previously, various economic studies have been performed with respect to the Klamath Basin and its many programs, projects, and plans. In particular, the US Department of the Interior conducted an economic analysis of proposed dam removal in 2012 that followed principles and guidelines developed by the United States Water Resources Council in 1983. As described in that framework, the federal objective is to contribute to national economic development (NED) consistent with protecting the nation's environment. A central concept to such studies is net economic benefits that are a measure of the extent to which society is better or worse off as a result of the proposed action, including both market and non-market benefits and

costs. The Klamath NED analysis evaluated the net economic benefits of dam removal that included a partial facilities-removal scenario. Accordingly, based on the DOI study, benefits and costs over the project life were estimated in 2012 dollars, with future values discounted back to year 2012 using 4.125 percent discount per the 2011 Federal Water Resources Planning Rate. Computations determined that the low range estimate for net economic benefits was $14.1 billion with a corresponding benefit-cost ratio of 8.7 to 1; the high range estimate was $82.7 billion (47.6 to 1). Even for the non-economist, these aggregated figures suggest the significant benefits of dam removal and river restoration.

More specifically, estimation of net economic benefits was based on analysis of the following categories: commercial fishing, in-river sport fishing, ocean sport fishing, irrigated agriculture, refuge recreation, nonuse values, tribal effects, hydropower, project costs (facilities removal, site mitigation, river restoration), reservoir recreation, and whitewater recreation. The evaluation of hydropower, reservoir recreation, and whitewater recreation resulted in foregone benefits, implying that benefits for these activities with dam removal are less than benefits with the dams remaining in place. It should be noted that costs and benefits that could not be monetized were not reflected in the benefit-cost ratio but were considered qualitatively. These included tribal resource values, hydropower ancillary services, and steelhead and redband trout fisheries. Tables 4–8 summarize economic findings from the DOI.

The highest economic benefit predicted is in commercial fishing ($134.5 million) and yet this may be an underestimate if rather than competitive fishing strategies, fishermen used more traditional (and efficient) coordinated (Ostrom-style) tribal systems in a post-dam Klamath River future.[87] Overall, one is left with a sense of cautious optimism that above and beyond the assumptions and constraints of classical economics (and *homo economicus*), the broader confluence of science, policy, and practice can also be informed and shaped by local cultural knowledge, including indigenous systems, to facilitate more appropriate technology and sustainable communities.[88]

Integrative dam assessment modeling (IDAM). Given the difficult issues of the Klamath Basin and the numerous and often narrowly focused studies sponsored by different interest groups, a more cohesive, transparent, and multidisciplinary approach is needed to advance data collection, analysis, and interpretation. This should be done in a culturally relevant and appropriate way. Most studies of benefits and costs of dam construction and deconstruction are completed from a single disciplinary perspective such as economics or engineering, with limited integration and applicability. Based on the substantial biophysical, socioeconomic, and geopolitical implications related to the

Table 4
Summary of Economic Benefits

Benefits	Removal of Dams ($ M, 2012 dollars, change from No Action Alternative)
Irrigated agriculture	29.9
Commercial fishing	134.5
Ocean sport fishing	52.8
In-river salmon sport fishing	1.8
Refuge recreation	4.3
Nonuse values	
Local	67 217
Region	2091 9071
US	13487 74983
Total (low – high estimate)	**15,868 - 84,435**

Source: DOI, 2012

Table 5
Summary of Unquantified Economic Benefits

Unquantified Benefits	Removal of Dams
Tribal commercial fisheries	Insufficient data but positive
Tribal cultural values	Applying economic frameworks to monetize tribal cultural values considered inappropriate; but effect positive
In-river steelhead & redband trout sport fishing	Insufficient data but positive
Refuge wildlife viewing	Insufficient data but positive

Source: DOI, 2012

Table 6
Summary of Economic Costs

Costs	Removal of Dams ($ M, 2012 dollars, change from No Action Alternative)
River restoration	474.1
Facilities removal	129.1
Site mitigation	37.7
Operations & monitoring	-188.9
Forgone hydropower benefits	1320.1
Forgone reservoir rec benefits	35.4
Forgone whitewater rec benefits	6.1
Total (low – high estimate)	**1,772 – 1,814**

Source: DOI, 2012

Table 7
Summary of Unquantified Economic Costs

Unquantified Costs	Removal of Dams
Real estate values	Insufficient data given magnitude, time, potential double counting
Hydropower ancillary services	Outside scope, aspects such as transmission of electricity
Regional power plant emissions	Outside scope, system wide emission or regional air quality

Source: DOI, 2012

Table 8
Summary of Calculated Values

Total Values	Removal of Dams ($ M, 2012 dollars, change from No Action Alternative)
Net Economic Benefits	**14,055 – 82,663**
Benefit-Cost Ratio (low – high estimate)	**8.7 to 1; 47.6 to 1**

Source: DOI, 2012

outcomes of this particular case for the region and, more broadly, society, use of an innovative technique is recommended. The IDAM tool represents such a capability.[89] With growing and oftentimes competing demands for water, energy, and natural capital, the IDAM tool is being used as part of impact evaluations for siting, sizing, constructing, and removing dams in the United States as well as in other countries such as China.[90] Designed by a National Science Foundation consortium of experts, the tool incorporates site-specific considerations based on twenty-seven individual impacts or effects of dam (de) construction. Each of these twenty-seven impacts includes both an objective evaluation of the magnitude of the effect (metric) and a subjective evaluation of the effect (valuation).

Multiple parameters are identified and assessed as part of the algorithm. For each of the overarching categories, further detailed factors are examined as follows: *biophysical impacts*: water retention time, nature value, downstream tributaries, biodiversity, distance of river downstream, CO^2 equivalent, flood protection, site stability, and reservoir surface; *socioeconomic impacts*: social cohesion, cultural change, non-agricultural activity, health, agricultural economic activity, displacement, hydropower/infrastructure, housing values, and transportation; *geopolitical impacts*: basin population affected, downstream irrigation, political boundaries, existing dams, agreements/institutions, political participation, historical stability/tensions, domestic governance, and socioeconomic impacts for non-constituents. These combined factors are determined for each impact and aggregated within the three themed areas (biophysical, socioeconomic, and geopolitical) and subsequently plotted; this process is flexible and can be scaled to fit the particular scope of a given project.

Beyond the technical information, this tool could be central to a participatory process that might foster community involvement and enhanced understandings of costs and benefits for decision-making. Key priorities and concerns especially relevant for the Klamath can range from tacit items which may or may not be accounted for in discussions and designs, to explicit factors worthy of mindful weighting, integration, and comparative analysis. Vital dimensions such as climate change, sociocultural cohesion, health, political jurisdictions, historical relations, and stakeholder engagement—not overtly addressed in a harmonized way in previous government benefit cost analyses, but important for tribal communities—may be brought to the forefront. The spiral amoeba graphics in figure 4 illustrate the types of visual outputs and impact areas generated by the approach.

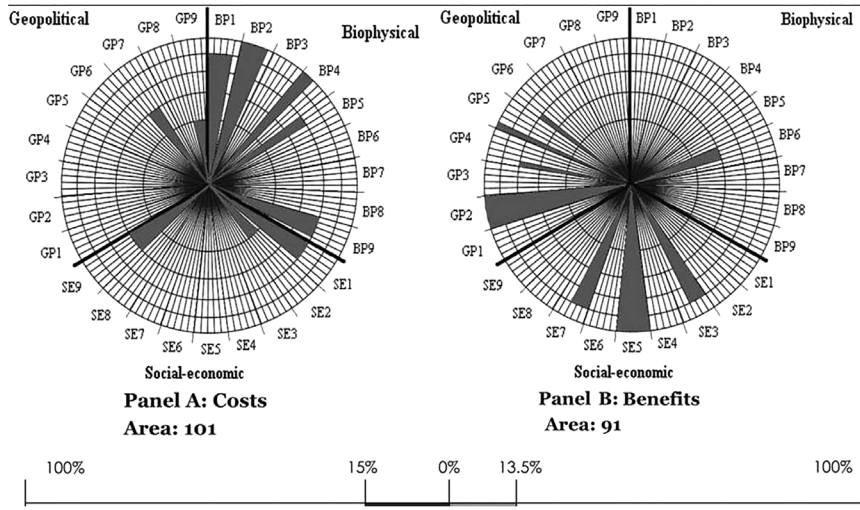

Figure 4. *IDAM Tool visual representing magnitude and salience for aggregated costs and benefits. Source: Brown, et al., 2009.*

Although upfront information is needed to run the model, data collected by various agencies and organizations are available, and the IDAM system could help guide efforts to organize and bridge data gaps. The tool could facilitate comprehensive scoping and visioning as part of public education and outreach activities. The graphical and holistic features could be used to complement existing plans and post-dam monitoring involving groups of diverse stakeholders. For example, the IDAM might be configured to interface with geographic information systems in an iterative way for adaptive management. Moreover, this could support community-based participatory research and ecoliteracy.

In summary, this tool could be used not only for research, but also as part of the broader strategy for implementation of the restoration agreement. As recently stated by Don Gentry, chairman of the Klamath Tribes, "Negotiating and signing this agreement is a very important and positive step in the efforts of the Klamath Tribes and irrigation community to resolve years of ongoing conflicts and court battles over water management affecting the tribes' fisheries and other treaty resources, and the economic stability of our community."[91]

Conclusion

Social ecological systems in the Klamath River Basin are multivalent, contested, and polycentric. With a long history and broad array of stakeholders, there have been conflicts over limited water and fish resources, including controversies concerning the role of scientific evidence in environmental policy implementation. Tribal governments have an important role in this unique puzzle and its outcomes. Utilizing the SES framework renders some baseline characterizations for consideration. Examination of past, present, and future scenarios suggests that indicators related to actors, governance, and resources are indeed central to ongoing transformation, and brief evaluation of economic tradeoffs provides an instructive outline for subsequent IDAM use. Stakeholder workshops and finalization of the settlement agreement are particularly encouraging for the Klamath Tribes and promising for the region. Although deconstruction of dams has become more acceptable in recent years, the underlying science of removal and associated data on ecological restoration are still emerging. Nevertheless, the removal of the Klamath dams could represent a tipping point toward more sustainable systems in the basin—developments with implications for environmental governance, natural resource management, and American Indian culture—worthy of further research.

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